

**CLAIMS:**

1. A frequency conversion circuit for direct conversion receiving which performs orthogonal transform on a received signal and converting the signal to an I signal and a Q signal, and is formed on the substrate of a semiconductor integrated circuit, comprising: a differential amplification circuit including an MIS field-effect transistor in which a projecting portion is formed by a silicon substrate having a first crystal surface as a primary surface and a second crystal surface as a side surface, terminated hydrogen on the silicon surface is removed in a plasma atmosphere of an inert gas, then a gate insulating film is formed on at least a part of a top surface and the side surface of the projecting portion at a temperature at or lower than about 550°C in the plasma atmosphere, a gate is formed on the gate insulating film, and a drain and a source are formed on both sides enclosing the gate insulating film of the projecting portion.

2. The frequency conversion circuit for direct conversion receiving according to claim 1, wherein the projecting portion has the top surface comprising a silicon surface (100), the side surface

comprising a silicon surface (110), and the source and drain are formed on the projecting portion enclosing the gate and in left and right areas of the projecting portion of the silicon substrate.

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3. The frequency conversion circuit for direct conversion receiving according to claim 1 or 2, wherein

the frequency conversion circuit comprises a p-channel MIS field-effect transistor and n-channel MIS field-effect transistor, and a gate width of a top surface and a side surface of a projecting portion of the p-channel MIS field-effect transistor is set such that current drive capability of the p-channel MIS transistor can be substantially equal to current drive capability of the n-channel MIS transistor.

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4. The frequency conversion circuit for direct conversion receiving according to claim 1 or 2, wherein

the frequency conversion circuit comprises: a first mixer circuit comprising: a differential amplification circuit comprising the plurality of MIS field-effect transistors for receiving a received signal at each gate; and a differential amplification circuit comprising the plurality of MIS field-effect transistors for receiving a first local oscillation

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signal at each gate, and mixing the first local oscillation signal with the received signal; a second mixer circuit comprising: a differential amplification circuit comprising the plurality of MIS field-effect transistors for receiving a received signal at each gate; and a differential amplification circuit comprising the plurality of MIS field-effect transistors for receiving a second local oscillation signal having a  $90^\circ$  phase difference to the first local oscillation signal at each gate, and mixing the received signal with the second local oscillation signal; a local oscillation circuit for generating the first local oscillation signal; and a phase shifter for outputting the second local oscillation signal having the  $90^\circ$  phase difference to the first local oscillation signal.

5. A semiconductor integrated circuit for direct conversion receiving which performs orthogonal transform on a received signal and converting the signal to an I signal and a Q signal, and is formed on the substrate of a semiconductor integrated circuit, comprising: a circuit including: a p-channel MIS field-effect transistor and an n-channel MIS field-effect transistor in which a projecting portion is formed by a silicon substrate having a first crystal

surface as a primary surface and a second crystal surface as a side surface, terminated hydrogen on the silicon surface is removed in plasma atmosphere of an inert gas, then a gate insulating film is formed on at least a part  
5 of a top surface and the side surface of the projecting portion at a temperature at or lower than about 550°C in the plasma atmosphere, a gate is formed on the gate insulating film, and a drain and a source are formed on both sides enclosing the gate insulating film of the  
10 projecting portion; and a frequency conversion circuit having a differential amplification circuit including the p-channel MIS field-effect transistor or the n-channel MIS field-effect transistor.

15 6. The semiconductor integrated circuit for direct conversion receiving according to claim 5, wherein  
gate widths of a top surface and a side surface of the projecting portion of the p-channel MIS field-effect transistor and the n-channel MIS  
20 field-effect transistor are set such that the current drive capability of the p-channel MIS field-effect transistor can be substantially equal to current drive capability of the n-channel MIS field-effect transistor.

7. The semiconductor integrated circuit for direct conversion receiving according to claim 5 or 6, wherein the frequency conversion circuit comprises a CMOS circuit having the p-channel MIS field-effect transistor and the n-channel MIS field-effect transistor.

8. A direct conversion receiver comprising on a substrate of a semiconductor integrated circuit: a frequency conversion circuit having a differential amplification circuit formed by an MIS field-effect transistor in which a projecting portion is formed by a silicon substrate having a first crystal surface as a primary surface and a second crystal surface as a side surface, terminated hydrogen on the silicon surface is removed in a plasma atmosphere of an inert gas, then a gate insulating film is formed on at least a part of a top surface and the side surface of the projecting portion at a temperature at or lower than about 550°C in the plasma atmosphere, a gate is formed on the gate insulating film, and a drain and a source are formed on both sides enclosing the gate insulating film of the projecting portion; and a DC amplifier having a differential amplification circuit formed by the MIS field-effect transistor.

9. A direct conversion receiver comprising on a substrate of a semiconductor integrated circuit: a frequency conversion circuit having a differential amplification circuit formed by an MIS field-effect transistor in which a projecting portion is formed by a silicon substrate having a first crystal surface as a primary surface and a second crystal surface as a side surface, terminated hydrogen on the silicon surface is removed in a plasma atmosphere of an inert gas, then a gate insulating film is formed on at least a part of a top surface and the side surface of the projecting portion at a temperature at or lower than about 550°C in the plasma atmosphere, a gate is formed on the gate insulating film, and a drain and a source are formed on both sides enclosing the gate insulating film of the projecting portion; and low noise amplifier formed by the MIS field-effect transistor.

10. A direct conversion receiver comprising on a substrate of a semiconductor integrated circuit: a frequency conversion circuit having a differential amplification circuit formed by an MIS field-effect transistor in which a projecting portion is formed by a silicon substrate having a first crystal surface as

a primary surface and a second crystal surface as a side surface, terminated hydrogen on the silicon surface is removed in a plasma atmosphere of an inert gas, then a gate insulating film is formed on at least a part of a top surface and the side surface of the projecting portion at a temperature at or lower than about 550°C in the plasma atmosphere, a gate is formed on the gate insulating film, and a drain and a source are formed on both sides enclosing the gate insulating film of the projecting portion; a DC amplifier having a differential amplification circuit formed by the MIS field-effect transistor; and a low noise amplifier comprising the MIS field-effect transistor.